REMARKS

Prior to this Reply, Claims 1, 3-10, 12-19, 21-25 and 47-52 were pending. Through this Reply, Claims 4-8, 13-17, 22-25 and 49-51 have been amended, Claims 1, 3, 9, 10, 12, 18, 19 and 21 have been cancelled, and Claims 53-102 have been added. Accordingly, Claims 4-8, 13-17, 22-25 and 47-102 are now at issue in the present case.

I. Rejections Under 35 U.S.C. § 102(b)

The Examiner rejected Claims 1 and 9 under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 3,895,270 to Maddox (hereinafter "Maddox").

Claims 1 and 9 have been cancelled without prejudice to, or disclaimer of, the subject matter contained therein.

Therefore, Applicants respectfully request that these rejections be withdrawn.

II. Rejections Under 35 U.S.C. § 103(a)

The Examiner rejected Claims 7, 8, 10, 16, 18, 19 and 24 under 35 U.S.C. § 103(a) as being unpatentable over Maddox in view of U.S. Patent No. 6,570,727 to Tamura et al. (hereinafter "Tamura").

The Examiner also rejected Claims 3 and 12 under 35 U.S.C. § 103(a) as being unpatentable over Maddox in view of U.S. Patent No. 6,747,823 to Saito et al. (hereinafter "Saito").

The Examiner also rejected Claims 17, 21 and 25 under 35 U.S.C. § 103(a) as being unpatentable over Maddox and Tamura and further in view of Saito.

Claim 7 has been rewritten in independent form to include the limitations of Claims 4, 5 and 6. The Examiner objected to Claims 4-6 as being dependent upon a rejected base claim, but indicated that such claims would be allowable if rewritten in independent form to include the limitations of their respective base claims and any intervening claims. Therefore, Claim 7 is allowable.

Claim 8 has been amended to depend from Claim 7.

Claim 16 has been rewritten in independent form to include the limitations of Claim 13. The Examiner objected to Claim 13 as being dependent upon a rejected base claim, but indicated that such claim would be allowable if rewritten in independent form to include the limitations of its base claim and any intervening claims. Therefore, Claim 16 is allowable.

Claim 17 has been amended to depend from Claim 16.

Claim 24 has been rewritten in independent form to include the limitations of Claims 22 and 23. The Examiner objected to Claims 22 and 23 as being dependent upon a rejected base claim, but indicated that such claims would be allowable if rewritten in independent form to include the limitations of their respective base claims and any intervening claims. Therefore, Claim 24 is allowable.

Claim 25 has been rewritten in independent form to include the limitations of Claim 23. The Examiner objected to Claim 23 as being dependent upon a rejected base claim, but indicated that such claims would be allowable if rewritten in independent form to include the limitations of its base claim and any intervening claims. Therefore, Claim 25 is allowable.

Claims 3, 10, 12, 18, 19 and 21 have been cancelled without prejudice to, or disclaimer of, the subject matter contained therein.

Therefore, Applicants respectfully request that these rejections be withdrawn.

III. Claim Objections

Claims 4-6, 13-15, 22 and 23 have been rewritten in independent form to include the limitations of their respective base claims and any intervening claims. The Examiner indicated that such claims would be allowable if rewritten in independent form to include the limitations of their respective base claims and any intervening claims.

Therefore, Applicants respectfully request that these objections be withdrawn.

IV. Other Claim Amendments

The claims have been amended to improve clarity. No new matter has been added.

V. New Claims

Claim 53 recites "the rate of reducing the magnetic field is based on the rotational speed of the disk." Applicants submit that the above-quoted limitation is not disclosed by the prior art of record, as the Examiner correctly noted by indicating that Claim 13 would be allowable if rewritten in independent form to include the limitations of its base claim and any intervening claims. Therefore, Claim 53 is allowable. Claims 54-82 depend on Claim 53 and are believed to be allowable for at least the same reasons as Claim 53.

Claim 83 is believed to be allowable for at least the same reasons as Claim 53. Claims 84-102 depend from Claim 83 and are believed to be allowable for at least the same reasons as Claim 83.

VI. Amendments to the Specification

A substitute specification without claims (and a marked-up version thereof) is provided herein under 37 C.F.R. 1.125 to improve clarity of the specification. No new matter has been added. Applicants respectfully request that the substitute specification be entered.

Applicants note that the title of the invention has been amended as set forth in the substitute specification. Applicants respectfully request the U.S. Patent and Trademark Office to update its records, including its electronic records, to reflect the new title.

VII. Amendments to Drawings

Applicants are submitting replacement Figures 1, 2A, 2B, 3A, 3B, 4A, 4B, 5-9, 10A, 10B, 10C, 11A, 11B, 12A, 12B and 12C (contained on replacement sheets 1-12) to improve the quality of the drawings.

Figures 1A, 1B, 1C, 1D, 2A, 2B, 2C, 3A, 3B, 4A, 4B, 4C, 5, 6A, 6B, 7A, 7B, 7C and 7D in the original application have been renumbered as Figures 2A, 2B, 3B, 5, 4A, 4B, 1, 11A, 11B, 7, 6, 10A, 8, 12A, 12B, 9, 10B, 10C and 12C, respectively, in the replacement sheets. Figure 3A has been added to the replacement sheets.

Figure 1 has been modified to clarify apparatus 10, controller 12, power source 14, electromagnet 16, spin motor 20 and monitor 22 and to delete housing 21.

Figure 2A has been modified to clarify electromagnets 16a and 16b, disk 24, coils 26a and 26b and magnetic field 28a and to delete the text and reference numeral 10.

Figure 2B has been modified to clarify electromagnets 16a and 16b and disk 24, to show an arrow depicting rotation of disk 24 and to delete the circle between the ID and OD.

Figure 3A has been added to show electromagnets 16c and 16d, disk 24, coils 26c and 26d and magnetic field 28c.

Figure 3B has been modified to clarify electromagnets 16c and 16d, disk 24 and the ID and OD of disk 24 and to delete reference numeral 12 and the circle between the ID and OD.

Figure 4A has been modified to clarify electromagnets 16e and 16f, disk 24, coils 26e and 26f and magnetic fields 28e and 28f and to delete reference numerals 10 and 12b.

Figure 4B has been modified to clarify electromagnets 16e and 16f, disk 24 and the ID and OD of disk 24, to show an arrow depicting rotation of disk 24 and to delete reference numeral 12 and the circle between the ID and OD.

Figure 5 has been modified to renumber steps 11, 13, 15 and 17 as steps 30, 32, 36 and 38, respectively, at step 30 to change "electromagnets" to "electromagnet" and "disk(s)" to "disk" and at step 32 to change "electromagnets" to "electromagnet" and "an initial level essentially" to "high strength" and at step 36 to change "initial level" to "high strength" and "lower level" to "low strength" and to delete "the" and at step 38 to delete "the" and to show step 34 between steps 32 and 36.

Figure 6 has been modified to clarify disk 24, disk drive 40, transducer head 42, actuator assembly 44, voice coil motor 46, spindle motor 48, preamplifier 50, read/write channel 52, power driver 54, controller 56, memory 58, tracks 60, read element 62, write element 64, microcontroller 66, drive controller 68 and memory 70 and to delete reference numerals 14, 100, 120 and 122 and to delete "AC Erase" in both controller 56 and memory 58.

Figure 7 has been modified to renumber steps 34, 36, 38, 40, 42, 44 and 46 as steps 100, 102, 104, 106, 108, 110 and 112, respectively, at step 102 to change "write clock" to "low recording" and at step 104 to change "selected" to "current recording" and at step 106 to delete

“,” and at step 110 to change “write” to “recording” and at step 112 to change “Write on all data tracks at the current write frequency to erase.” to “Select current recording frequency for AC erase.”

Figure 8 has been modified to renumber steps 152, 154, 156 and 158 as steps 120, 122, 124 and 126, respectively, at step 120 to change “disks” to “magnetic material on disk” and at step 122 to change “Perform media test” to “Test disk” and at step 124 to change “disks” to “disk” and at step 126 to change “Perform servo writing” to “Servo write” and to insert “disk” after “test.”

Figure 9 has been modified to renumber steps 160, 162, 164, 166, 168 and 170 as steps 130, 132, 134, 136, 138 and 140, respectively, at step 130 to change “regions” to “disk area” and to insert “transducer” before “head” and at step 132 to change “erase DC” to “DC erase” and to delete “for the head” and at step 138 to insert “transducer” before “head” and at step 140 to change “head” to “DC erase” and to label step 142.

Figure 10A has been modified to clarify disk 24, transducer head 42, write element 64 and magnetic field 150A, to insert “AC Erase” at the top of the figure.

Figure 10B has been modified to clarify disk 24, transducer head 42, write element 64 and magnetic field 150B, to insert “+DC Erase” at the top of the figure.

Figure 10C has been modified to clarify disk 24, transducer head 42, write element 64 and magnetic field 150C, to insert “-DC Erase” at the top of the figure.

Figure 11A has been modified to clarify AC band erase 160, +DC band erase 162, -DC band erase 164, to reorient “BER” at the left, and to change “W idth” to “Width.”

Figure 11B has been modified to clarify AC band erase 170, +DC band erase 172, -DC band erase 174, to change “W idth” to “Width,” and to change and reorient “Bit Shift (%)” to “Transition Shift (%).”

No new matter has been added. Figures 1, 2A, 2B, 3A, 3B, 4A, 4B, 5-9, 10A, 10B, 10C, 11A, 11B, 12A, 12B and 12C constitute all of the drawings of the application.

VIII. Additional Claim Fees

In determining whether additional claim fees are due, reference is made to the Fee Calculation Table (below).

Fee Calculation Table

	Claims Remaining After Amendment		Highest Number Previously Paid For	Present Extra	Rate	Additional Fee
Total (37 CFR 1.16(c))	70	Minus	46	= 24	x $50 =	$ 1200.00
Independent (37 CFR 1.16(b))	17	Minus	7	= 10	x $200 =	$2000.00

As set forth in the Fee Calculation Table (above), Applicants previously paid claim fees for forty-six (46) total claims and for seven (7) independent claims. Therefore, Applicants hereby authorize the Commissioner to charge the credit card identified on the enclosed Form PTO-2038 in the amount of $3200.00 for the presentation of twenty-four (24) total claims over forty-six (46) and ten (10) independent claims over seven (7). Although Applicants believe that no other fees are due, the Commissioner is hereby authorized to charge Deposit Account No. 50-2198 for any fee deficiencies associated with filing this paper.

IX. Conclusion

It is believed the above comments establish patentability. Applicants do not necessarily accede to the assertions and statements in the Office Action, whether or not expressly addressed.

Applicants believe that the application appears to be in form for allowance. Accordingly, reconsideration and allowance thereof is respectfully requested.

The Examiner is invited to contact the undersigned at the below-listed telephone number regarding any matters relating to the present application.

Respectfully submitted,

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MARKED-UP VERSION OF
SUBSTITUTE SPECIFICATION UNDER 37 C.F.R. 1.125

Demagnetization of Magnetic Media for Data Storage Device using Gradually Reduced Magnetic Field~~Media Preconditioning for Perpendicular Recording in Disk Drives~~

b~~B~~y
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Steven Lambert
Steven Marshall
and
George Bellesis

Field of the Invention

The present invention relates~~d~~ to magnetic recording, and in particular to demagnetization of magnetic media~~magnetic recording of data in data storage devices~~.

Background of the Invention

Data storage devices often use magnetic recording to store data on magnetic media. For instance, a disk drive includes a transducer head and a magnetic disk. The~~Storage devices such as disk drive utilize a magnetic disk and~~ transducer head includes a read element that ~~for~~ magnetically reads~~record ing~~ data from~~and reading data from~~ ~~concentric tracks on~~ the ~~magnetic~~ disk and a write element that magnetically records (writes) data on the disk. The disk is magnetic media that stores the data in concentric tracks.

In longitudinal recording~~of data~~, data ~~information~~ is stored on the disk ~~magnetized~~ in horizontal transitions (bits) that are ~~recorded horizontally,~~ parallel to the ~~surface of the magnetic~~ disk. In perpendicular recording, data is stored on

the disk in vertical ~~the magnetic~~ transitions (bits) that are perpendicular to the disk ~~surface, allowing storage of more data~~. Perpendicular recording allows for greater data storage than longitudinal recording since ~~In longitudinal recording~~data stored at high areal density ~~the recorded data~~ degrades less over time in perpendicular recording than in longitudinal recording ~~as indicated by degradation in the amplitude of the readback signal. Perpendicular recording can also suffer from this effect.~~.

In perpendicular recording, the write element includes a large pole and a small pole, and the large pole has larger dimensions than the small pole. The disk includes a soft underlayer that collects the magnetic field from a large area and couples the magnetic field to the large pole. As a result, the transducer head is biased during write operations due to the magnetic field from other tracks being coupled to the large pole. The bubble, where data is written to the disk, either expands or contracts due to the magnetic field.

Disk preconditioning plays a major role in disk drive performance. Disk preconditioning involves demagnetizing (erasing) the disk before data is recorded on the disk. Disk drive performance includes bit error rate (BER) represented by the number of bits in error read from the disk in a readback signal divided by the number of bits read from the disk in the readback signal.

DC erase applies an essentially constant current to the write element to demagnetize the disk. DC erase is typically applied to disk areas for servo wedges and user data before data is recorded on the disk. Thereafter, data such as servo patterns and user data is initially recorded on the disk.

DC erase in longitudinal recording has negligible effects since the disk lacks a soft underlayer. However, in perpendicular recording, DC erase

increases the BER in the readback signal from the recorded data by up to two orders of magnitude since the soft underlayer couples the magnetic field from the DC erased area to the write element as the data is written to the disk. The magnetic coupling enhances one polarity of the writing and degrades the other such that the positive or negative bit cells last longer than the other. Thus, the magnetic coupling causes transition shift on the disk. The transition shift creates timing asymmetry during read operations, and the timing asymmetry degrades the BER. As a result, the DC erase has a large negative impact on disk drive performance.

~~In perpendicular recording, DC band erase has a large impact on the Bit Error Rate (BER) performance of the disk drive (BER is a way to measure quality of data retrieved back after storage, represented by the number of bits in error divided by the number of bits transferred). In DC erase an essentially constant current is applied to the write head to erase data stored on the disk.~~

~~In perpendicular/vertical recording the magnetic transition is perpendicular to the disk surface. The write head has two poles, wherein one of the two poles has a larger dimension than the other, such that in DC erase for a wide range of tracks, the DC field couples into one of the two poles. When writing data, the head has a bias due to flux from the other tracks into the write pole. The bubble, where the data is written to the disk, either expands or contracts because of the magnetic field.~~

~~The reason for the change in BER is due to the transition shift caused by the magnetic field from the adjacent area of the disk coupling into the write head while it is writing. This effect is substantial for perpendicular recording because the soft under-layer of magnetic layer allows the magnetic flux to couple efficiently into the write head. The effect is negligible for longitudinal recording because there is no soft underlayer to help with collecting magnetic flux from a large area. In longitudinal recording, the medium is DC erased after it is~~

~~assembled into the disk drive, which degrades the disk drive performance for perpendicular recording.~~

There is, therefore, a need for an improved technique for demagnetizing the magnetic media~~method and apparatus~~ for a data storage device that reduces or eliminates the effect of the adjacent ~~medium~~ magnetic field on the data that is subsequently ~~track~~ written to the magnetic media ~~in perpendicular~~.

~~Brief~~ Summary of the Invention

~~The present invention satisfies these needs. For perpendicular recording, media preconditioning plays a major role in determining the drive servo and Bit Error Rate (BER) performances. This effect is due to the medium magnetic field from the adjacent area which can couple into the write head while the data track is being written.~~ The present invention provides an AC erase to precondition magnetic media and ~~provides a procedure to~~ minimize the effect of the adjacent ~~medium~~ magnetic field on the data that is subsequently written to the magnetic media ~~track, wherein the procedure include preconditioning the media by AC erasing the media~~.

In an~~one~~ embodiment ~~the present inve~~, ~~ntion provides a method of~~ demagnetizing magnetic media for recording data in a data storage device~~,~~ includ~~ing the s~~e~~teps~~ ~~of~~ placing the magnetic media in a magnetic field at a first strength level,~~;~~ and gradually reducing the magnetic field to a second strength level to essentially eliminate net magnetization in the magnetic media.

In a ~~A~~nother embodiment, ~~of a method of~~ demagnetizing magnetic media for recording data in a data storage device includes~~, comprises the steps of:~~ determining a recording frequency for writing on the magnetic media ~~with a transducer head,~~ at which the amplitude of a~~the~~ ~~transducer head~~ readback signal ~~from said portion of the magnetic media~~ is essentially at noise level,~~;~~ and writing

on the magnetic media at essentially ~~substantially~~ the ~~said~~ recording frequency~~,~~ to essentially ~~substantially~~ eliminate net magnetization in the magnetic media.

In another embodiment, demagnetizing magnetic media for recording data in a data storage device includes selecting multiple consecutive tracks on the magnetic media, and writing on the magnetic media by alternating the polarity of the write current from one track to the next to essentially eliminate net magnetization in the magnetic media.

Advantageously, the AC erase improves both servo operation and BER compared to conventional DC erase.

Brief Description of the Drawings

These and other features, aspects and advantages of the present invention will become understood with reference to the following description, appended claims and accompanying figures where:

FIG. 1 shows an apparatus for AC bulk erase of a disk;

FIGs. 2~~1~~A and ~~-~~2B~~C~~ show a first configuration ~~example method~~ of an ~~using~~ electromagnet~~s~~ in the apparatus of FIG. 1~~to erase disks according to the present invention~~;

FIGs. 3A and 3B show a second configuration of an electromagnet in the apparatus of FIG. 1;

FIGs. 4A and 4B show a third configuration of an electromagnet in the apparatus of FIG. 1;

FIG. 5~~1D~~ shows a ~~n example~~ flowchart for demagnetizing ~~of steps of erasing~~ a disk~~(s)~~ in the apparatus of FIG. 1 by AC bulk erase~~according to the present invention~~;

~~FIGs. 2A-B show a second example method of using electromagnets to erase disks according to the present invention;~~

~~FIG. 2C shows an example block diagram of apparatus for erasing heads according to the present invention;~~

~~FIG. 3A shows example plots illustrating the increase in BER for the readback signal from data recorded on data tracks when conventional process of band DC erase is used before writing data tracks compared to AC erase according to the present invention;~~

~~FIG. 3B shows example plots illustrating the transition shift with respect to the width of the erase band for convention DC erase compared to AC erase according to the present invention;~~

FIG. 6 shows a disk drive in which AC erase of a disk can be implemented;

FIG. 7~~4A~~ shows a flowchart for determining a recording frequency for AC erase of a disk in the disk drive of FIG. 6~~n example flowchart of another embodiment of a method of erasing disks according to the present invention~~;

~~FIG. 4B shows a simplified block diagram of an example a disk drive in which an embodiment of the present invention can be implemented;~~

~~FIG. 4C shows an example diagram of head flux due to AC bias current according to the present invention;~~

FIG. 8~~5~~ shows a flowchart for ~~of another embodiment of the method of present invention~~demagnetizing a disk in the disk drive of FIG. 6 by omitting the DC erase;

~~FIG. 6A shows an example plot illustrating a timing histogram of differentiated data written after a conventional DC band erase;~~

~~FIG. 6B shows readback signal measurement for data track written on as-received media after a disk sputtering process without any net magnetization, by turning off write current in regions that are normally DC erased, according to the present invention;~~

FIG. 9~~7A~~ shows a~~n example~~ flowchart for ~~of a method of~~ demagnetizing a disk in the disk drive of FIG. 6 ~~disk(s) according to the present invention~~ by DC erase~~ing~~ with alternate polarity of the write~~DC erase~~ current each time the transducer head is stepped;

FIG. 10A shows a magnetic field from a transducer head in the disk drive of FIG. 6 due to AC erase;

FIG~~s~~. 10~~7~~B~~-C~~ shows a magnetic field ~~example diagrams of head flux~~ from a transducer head in the disk drive of FIG. 6 due ~~due~~ to +DC erase~~and -DC alternating polarity bias current of the embodiment in FIG. 7A~~;

FIG. 10C shows a magnetic field from a transducer head in the disk drive of FIG. 6 due to -DC erase;

FIG. 11A shows comparative plots of BER as a function of erase band width for AC band erase and DC band erase;

FIG. 11B shows comparative plots of transition shift as a function of erase band width for AC band erase and DC band erase;

FIG. 12A shows a readback signal timing histogram of differentiated data written on a disk after a conventional DC band erase;

FIG. 12B shows a readback signal timing histogram of data written on a disk with as-received sputtered magnetic material; and

FIG. 12C~~7D~~ shows a readback signal timing histogram of data written on a disk after alternate +DC erase and -DC erase as a transducer head is stepped~~shows example plot illustrating readback signal of data written on media preconditioned by DC erasing with alternate polarity on adjacent tracks, according to the method in FIG. 7A~~.

Detailed Description of the Invention

FIG. 1 shows an apparatus 10 for AC bulk erase of a disk 24. The apparatus 10 includes a controller 12, a power source 14, an electromagnet 16, a spin motor 20 and a monitor 22. The disk 24 is perpendicular recording magnetic media with an areal density of 50Gb/in^2. The disk 24 is placed on the spin motor 20, and the electromagnet 16 is positioned near the disk 24.

The controller 12 controls the current generated by the power source 14 (a programmable direct current source) and thereby controls the magnetic field generated by the electromagnet 16. The spin motor 20 rotates the disk 24. The

monitor 22 monitors the rotational speed of the disk 24, and the controller 12 decrements the magnetic field to zero based on the rotational speed of the disk 24. Alternatively, the monitor 22 is omitted, and the controller 12 decrements the magnetic field to zero based on a predetermined rotational speed of the disk 24.

FIGs. 2A and 2B show a first configuration of the electromagnet 16 shown as electromagnets 16a and 16b. The electromagnets 16a and 16b are ~~Conventional DC erase methods degrade the bit error rate (BER) in readback signal (e.g., 2 orders of magnitude increase) from data recorded on data tracks after such DC erase. This is because the magnetic field from the DC erased regions couple into the head writer element, resulting in transition shifts. Coupling of the magnetic field from the DC erased regions into the head enhances one polarity of writing and degrades the other with the result that either positive or negative bit cells last longer than the other polarity. This timing asymmetry degrades the BER, and has a substantial negative impact on the BER performance of disk drives because many parts of the medium in servo wedges and unused parts of the data zone are conventionally DC erased.~~

~~Example methods of eliminating the above effect according to the present invention, include performing AC erase of data tracks before writing data.~~

~~FIGs. 1-2 show two different example apparatus 10 and methods, (Configuration 1 and Configuration 2, respectively), to perform AC bulk erase according to an aspect of the present invention. Referring to FIGs. 1A-C, according to example steps in flowchart of FIG. 1D, two~~ U-shaped magnets ~~12 (e.g., electromagnets) are used wherein the magnets 12 are~~ positioned near~~on the~~ opposite major surface~~ides~~ of the ~~a~~ disk 2~~1~~4 with poles that are perpendicular to the disk 24 and a gap between the poles that is spaced from the disk 24. The electromagnets 16a and 16b are coupled to coils 26a and 26b, respectively, and generate a magnetic field 28a that is perpendicular to and extends through the disk 24. The electromagnets 16a and 16b cover ~~, covering at least~~ a radial

section of the disk 2~~1~~4 between the inner diameter (ID) and the outer diameter (OD) of the disk 24 and move from the ID to the OD (or the OD to the ID) to cover the entire width of the disk 24~~as shown in FIGs. 1A-B (step 11)~~.

FIGs. 3A and 3B show a second configuration of the electromagnet 16 shown as electromagnets 16c and 16d. The electromagnets 16c and 16d are U-shaped magnets positioned near opposite major surfaces of the disk 24 with poles that are perpendicular to the disk 24 and a gap between the poles that is spaced from the disk 24. The electromagnets 16c and 16d are coupled to coils 26c and 26d, respectively, and generate a magnetic field 28c that is perpendicular to and extends through the disk 24. The electromagnets 16c and 16d cover a radial section of the disk 24 between the ID and the OD of the disk 24 and cover the entire width of the disk 24.

FIGs. 4A and 4B show a third configuration of the electromagnet 16 shown as electromagnets 16e and 16f. The electromagnets 16e and 16f are U-shaped magnets positioned near opposite minor surfaces of the disk 24 with poles that are parallel to the disk 24 and a gap between the poles that is occupied by the disk 24. The electromagnets 16e and 16f are coupled to coils 26e and 26f, respectively, and generate magnetic fields 28e and 28f, respectively, that are perpendicular to and extend through the disk 24. The electromagnets 16e and 16f cover a radial section of the disk 24 between the ID and the OD of the disk 24 and cover the entire width of the disk 24.

The first and second configurations of the electromagnet 16 can be modified to simultaneously erase multiple disks 24. The distance (open space) between the electromagnets 16a, 16b, 16c and 16d and the associated surfaces of the disk (or disks) 24 is 1 or 2 millimeters.

FIG. 5 shows a flowchart for demagnetizing the disk 24 in the apparatus 10 by AC bulk erase. The disk 24 is demagnetized as follows:

(a) The electromagnet 16 is placed near the recording surface of the disk 24 (step 30);

(b) The controller 12 applies a high current to the electromagnet 16 ~~As shown in FIG. 1B, the poles 12a of the magnet 12 are either moved from inner diameter (ID) to outer diameter (OD) to cover the disk surface, shown by broken arrow in FIG. 1B, or the magnet poles 12a are wide enough to cover the entire width of the disk surface (i.e., from the ID to the OD) as shown in FIG. 1C.~~

~~Referring to FIGs. 2A-B, in Configuration 2, two U-shaped magnets 12 are used wherein the disk 14 is positioned in a gap 12b of the magnets 12, and the magnets 12 are positioned about 180° apart, as shown in side and top views in FIGs. 2A-B, respectively.~~

~~In both configurations, AC erase of data tracks is performed by: powering the electromagnets 12~~ to generate an initial high strength magnetic field (such as 1 to 100 KGauss) that is perpendicular to and extends through the disk 24 and is based on and much higher than the magnetic coercivity of the disk 24 (step 32);

(c) The spin motor 20 rotates the disk 24 (step 34); and

(d) T~~12c between the magnets 12 (step 13), rotating the disk 14~~he controller 12 gradually reduces (continuously or stepwise) the high current to essentially zero current while the disk 24 rotates, and consequently ~~(shown by curved arrow in FIG. 1C) while~~ the magnetic field generated by the electromagnet~~s~~ 16~~2~~ is gradually ~~slowly~~ reduced from the high strength to a low strength that is ~~or level (e.g., zero) from the high starting field strength (about 1 KGauss to 100 KGauss) based on coercivity of the magnetic media on the disk 14 (step 15).~~ essentially non-existent (zero), thereby AC erasing the disk 24 (step 36).

The rate of reduction of the magnetic field depends on the rotational speed the disk 24. The faster the rotational speed of the disk 24, the faster the rate of reduction of the magnetic field.

For example, the magnetic field is decremented to zero at one decrement per revolution of the disk 24. Thus, the time elapsed for each decrement is the same as the time elapsed for a revolution of the disk 24. For instance, if the disk 24 rotates at 10 msec per revolution then the magnetic field is decremented every 10 msec. As another example, the magnetic field is decremented to zero at approximately one decrement per revolution of the disk 24. Thus, the time elapsed for each decrement is approximately the time elapsed for a revolution of the disk 24. For instance, if the disk 24 rotates at 10 msec per revolution then the magnetic field is decremented marginally longer than every 10 msec. As yet another example, the magnetic field is decremented to zero more slowly than one decrement per revolution of the disk 24. Thus, the time elapsed for each decrement is greater than the time elapsed for a revolution of the disk 24. For instance, if the disk 24 rotates at 10 msec per revolution then the magnetic field is decremented every 20 msec.

After the disk 24 is AC erased, the disk 24 is assembled into a disk drive and then user d~~D~~ata can ~~then~~ be written to ~~on~~ the disks 2~~1~~4 (step 38~~17~~). ~~As such, as shown by example in block diagram of the apparatus 10 in FIG. 2C, a power source 16 (e.g., programmable direct current source) is applied to the electro-magnets 12, wherein the amplitude of the current applied to the magnets 12 can be varied (e.g., continuously or stepwise) from a high current for a starting magnetic field to essentially zero current for an essentially non-existence magnetic field. The starting field strength of the electromagnet is selected so that it is much higher than the coercivity (Hc) of the magnetic media on disk surfaces.~~

~~The rate of reduction of magnetic field 12c depends on the speed of rotation of the disk 14. In one example, the magnetic field 12c is decremented to zero, approximately one decrement per revolution of the disk 14. The amount of time elapsed for each decrement is about the same or marginally longer than the time elapsed for a revolution of the disk. For example, if the disk rotates at~~

~~10 msec per revolution, then the magnetic field is decremented in more than 10 msec. The faster the speed of rotation, the faster the rate of reduction of the magnetic field. In another example, the amount of time elapsed for each decrement is more than the time elapsed for a revolution of the disk. For example, if the disk 14 rotates at 10 msec per revolution, then the magnetic field is decremented by one steps in more e.g. 20 msec, etc.~~

~~As shown in FIG. 2C, the AC erase is performed by placing one or more disks 14 in the eraser apparatus 10 further including a spin motor 18 for spinning/rotating disks 14, wherein the electromagnets 12 are positioned proximate the disks 14 as shown in FIGs. 1A-C and 2A-B. A controller 20 controls the level of e.g. current generated by the power source 16, and thereby controls the magnetic field generated by the magnets 12. Optionally a monitor 19 monitors rotational speed of the disks 14 whereby the controller 20 decrements the magnetic field to zero based on the rotational speed of the disks 14. In another version a monitor is not necessary, wherein based on a predetermined speed of rotation of the disks 14 the controller 20 decrements the magnetic field to zero. The apparatus 10 can further include a housing 21 for housing said components to erase disks 14 placed therein.~~

~~The Configurations 1, 2 above can be modified to erase multiple disks 14 at the same time. The distance between the magnets 12 and surfaces of disks 14 (e.g., 1 or 2 millimeter) is such as to provide magnetic fields perpendicular to the surface of the disk 14. After the above AC erase procedure, the disks 14 are assembled in disk drives for customer use.~~

~~Referring to FIG. 3A, example comparative plots illustrate bit error rate (BER) in readback signal for AC erase 22 according to the present invention, and degradation (e.g., 2 orders of magnitude increase) in BER for the readback signal from data recorded on data tracks when conventional process of only +DC~~

~~band erase 24 or only -DC band erase 26, is used before writing data tracks. This is because the magnetic field from the DC erased regions couple into the head writer element, resulting in transition shifts. FIG. 3B shows example comparative plots illustrating the transition shift with respect to the width of the erase band using AC erase 28 according to the present invention, and using conventional +DC and -DC erase 30, 32. Coupling of the magnetic field from the DC erased regions into the head enhances one polarity of writing and degrades the other with the result that either positive or negative bit cells last longer than the other polarity. This timing asymmetry degrades the BER, and has a substantial negative impact on the BER performance of disk drives because many parts of the medium in servo wedges and unused parts of the data zone are conventionally DC erased.~~

~~Referring to example steps in FIG. 4A, in another aspect of the present invention, the AC erase method includes AC erasing the disks (i.e., recording medium) in spin-stand or disk drive, at a frequency (F) determined by the following steps:~~

~~(a) Selecting e.g. the outer diameter (OD) of the disk as the test track 23 (e.g., FIG. 4B) (step 34) -- in other versions other test tracks such as inner diameter (ID), middle diameter (MD,, etc. can be selected;~~

~~(b) Setting the write clock/frequency to a nominal low frequency (e.g., about 50 to100 MHz) (steep 36);~~

~~(c) AC writing the test track at a nominal write data clock frequency (frequency of bits transitions) with write element of a transducer head 25 (e.g., FIG. 4B) (step 38);~~

~~(d) Reading back from the test track using read element of a head 25 after setting for write-read offset (because of offset distance between read and write elements in a head, after a write operation, the radial position of the head is adjusted by the offset distance to place read element over the test track to read), and measuring the amplitude of the read back signal (step 40);~~

~~(e) Increasing the write clock frequency and repeating steps 38, 40, until the amplitude of the readback signal reduces to noise level (the amplitude does not change any more as the write clock increases) (steps 42, 44); and~~

~~(f) Noting the clock frequency (F) at which the readback signal amplitude becomes low and relatively constant, and performing AC erase at or above clock frequency F on all data tracks to be erased (step 46).~~

~~At the start of the above process for searching for the AC erase write frequency, the noise level may not be known. The noise level is observed toward the end of the test at high frequency when the read signal amplitude is relatively constant as the write frequency is increased, indicating the readback signal amplitude is same as the noise level in the system. In the description herein, "noise level" is the level at which the averaged amplitude of the read signal remains relatively constant as write frequency increases.~~

~~The above steps can be performed in a spin-stand apparatus (test apparatus typically used to test head and media at the component level before assembled in disk drives), or in disk drives (e.g., FIG. 4B) after disks 14 are assembled therein.~~

~~Referring to~~ FIG. 6~~4B~~ shows a ~~, a simplified block diagram of an example~~ disk drive 4~~10~~0 in which AC erase of the disk 24 ~~an embodiment of the present invention~~ can be implemented. The disk drive 4~~1~~0~~0~~ includes the disk 24, a transducer head 42, an actuator assembly 44, a voice coil motor (VCM) 46, a spindle motor 48, a preamplifier 50, a read/write channel 52, a power driver 54, a controller 56 and a memory 58. The disk 24 includes tracks 60. The transducer head 42 includes a read element 62 and a write element 64. The controller 56 includes a microcontroller 66, a drive controller 68 and a memory 70.

The transducer head 42 uses the read element 62 and the write element 64 to read from and write to the disk 24. The actuator assembly 44 includes a

support arm that supports the transducer head 42. The VCM 46 moves the actuator assembly 44 and thus the transducer head 42 across the tracks 60, and maintains the actuator arm 44 and thus the transducer head 42 over a target track 60. The spindle motor 48 rotates the disk 24.

~~comprises storage medium such as data disks 14, and a disk drive controller 114 for interfacing with a host and controlling disk drive operations including data transfer to and from storage media 14, therein. The disk drive 100 further includes a head structure 116 including one or more heads 25 (each head 25 including a read element 25a and a write element 25b) moved by a support arm of an actuator assembly 120 via a VCM 122 across tracks of one or more disks 14 for data storage and data retrieval, and tracking to maintain the head over a target position.~~

The ~~Each disk 14 includes a servo pattern including multiple tracks 23 for data storage, on a recording surface thereof. The disk drive 100 further includes a~~ preamplifier 50~~124~~ ~~for~~ amplifies~~ying~~ the readback and write signals from and to the disk~~s~~ 24. The ~~14, respectively, and a~~ read/write channel 52 ~~126 for~~ encodes~~ing~~ and decodes~~ing~~ ~~data between user information and data written on disks 14. The channel 126 also decodes~~ servo track numbers and data and converts servo burst amplitudes into digital values. The ~~disk drive 100 further includes a~~ power driver 54 ~~IC 128 for~~ drives the VCM 46~~ing the actuator 120~~ and the ~~a~~ spindle motor 48~~130 for rotating the disks 14~~. The controller 56 interfaces with a host computer (not shown) and controls the operations of the disk drive 40. Within the controller 56, the ~~In one example embodiment, the controller 114 includes a memory 132,~~ microcontroller 66 ~~(e.g., microprocessor) 134 for~~ controls~~ling~~ the ~~head~~ bias current for the transducer head 42, and the ~~a~~ drive controller 68 ~~136 for~~ generally controls ~~of~~ the components of the disk drive 4~~10~~0. The ~~disk drive 100 can further include~~ memory 70~~142 for~~ stores ~~ing other~~ program instructions or data and ~~. The memory 142~~ can include RAM and/or non-volatile ~~(NV)~~ memory such as EEPROM, ROM, etc.

The controller 56 ~~disk drive firmware 114~~ or the memory 58~~142~~ can include the~~an~~ AC erase function~~ according to the above steps~~.

– After the disk drive 40 is assembled, a recording frequency for the AC erase is determined. Next, t~~Preferably t~~he transducer head 42 performs the AC erase ~~is performed~~ at the recording frequency on the disk 24 before ~~any~~ writing any data ~~is performed~~ on the disk 24. Thereafter, ~~s 14 (including writing~~ servo patterns and ~~in servowrite, and writing any~~ user data are written on the disk 24~~)~~.

~~After the disk drive 100 is assembled, AC band erase at the clock frequency (F) determined by the above procedure is programmed therein. The medium AC erase preconditioning according to the above steps improves both servo and data BER performances compared to conventional DC erase.~~

FIG. 7 shows a flowchart for determining the recording frequency for the AC erase of the disk 24 in the disk drive 40. The transducer head 42 reads from and writes to the disk 24. The recording frequency is the write clock frequency and therefore the frequency of the bit transitions written to the disk 24. The noise level is the level at which the averaged amplitude of the readback signal remains relatively constant as the recording frequency increases. The recording frequency is determined as follows:

(a) Select a test track 60 on the disk 24 (for instance at the inner diameter (ID), the middle diameter (MD) or the outer diameter (OD) of the disk 24) (step 100);

(b) Set the recording frequency to a nominal low frequency (such as 50 to 100 MHz) (step 102);

(c) AC write the test track 60 at the current recording frequency (step 104);

(d) Read the test track 60 (after adjusting the radial position of the transducer head 42 by the radially offset distance between the read element 62

and the write element 64 so that the read element 62 rather than the write element 64 is positioned over the test track 60) and measure the amplitude of the readback signal generated from the test track 60 (step 106);

(e) Compare the amplitude of the readback signal with the noise level (the amplitude of the readback signal is reduced to the noise level when the amplitude of the readback signal remains relatively constant as the recording frequency increases) (step 108);

(f) Increase the recording frequency and repeat steps 104, 106 and 108 if the amplitude of the readback signal is greater than the noise level (step 110); and

(g) Select the recording frequency at which the amplitude of the readback signal is reduced to the noise level as the recording frequency for the AC erase (step 112).

Thus, steps 104, 106 and 108 are repeated until the recording frequency is determined at step 112.

The AC erase is then performed on the tracks 60 on the disk 24 in the disk drive 40 by the transducer head 42 writing to the tracks 60 at the recording frequency at which the amplitude of the readback signal amplitude is reduced to the noise level.

The recording frequency can be scaled up or down to change the rotational speed (RPM) of the spindle motor 48, and thus the rotational speed of the disk 24, during the AC erase as long as the linear data density on the disk 24 is kept essentially constant. The AC erase is preferably performed on the area of the disk 24 that is intended for data storage.

The noise level may not be known before the recording frequency is determined. However, when the amplitude of the readback signal is relatively

constant as the recording frequency increases, this indicates that the amplitude of the readback signal is the same as the noise level.

Although the disk drive 40 is shown with a single disk 24 and a single transducer head 42, the disk drive 40 can include multiple disks 24 and multiple transducer heads 42, and the recording frequency can be used to AC erase multiple disks 24 in the disk drive 40. Furthermore, the recording frequency can be used to AC erase multiple disk drives 40.

Although the disk drive 40 is described as determining the recording frequency, alternatively a spin-stand can determine the recording frequency using the disk 24 and the transducer head 42. Thereafter, the disk 24 and the transducer head 42 are assembled in the disk drive 40, and the disk drive 40 performs the AC erase using the recording frequency determined by the spin-stand.

Although the disk drive 40 is described as AC erasing the disk 24, alternatively the apparatus 10 can AC erase the disk 24. Thereafter, the disk 24 is assembled in the disk drive 40, and the disk drive 40 need not AC erase the disk 24.

~~Preferably, the above steps of FIG. 4A are performed on a head 25 and disk 14 that are being used for the disk drive product 100. The clock frequency (F) can be scaled up or down if necessary to change the spindle 130 speed (RPM) for AC erase as long as the linear density of data is kept essentially constant. The AC erase is preferably performed on the area of the disk that is intended for data storage. Once the frequency F is determined for a disk drive 100, it can be used to AC erase multiple disk drives 100.~~

~~FIG. 4C shows an example diagram of head flux 150 from a head 25 due to AC erase according to the present invention. For the AC Erase precondition~~

~~case, when data is written to the tracks, the magnetic field 150 of the write head 25b is denoted by two down-arrows and two curved-arrows (magnetic bubbles). When the disk 14 (medium) is preconditioned with +DC Erase only or with - DC Erase only, the magnetic bubbles are either increased or decreased (depending on the direction of the write current) causing the written transition to expand or contract (number of curved arrows increase or decrease, respectively) and in turn causing transition shift.~~

FIG. 8 shows a flowchart for demagnetizing the disk 24 in the disk drive 40 by ~~According to another aspect of the present invention, an alternative method for demagnetizing the medium 14 includes~~ omitting the DC erase~~the steps of turning off head write current in regions that are normally DC erased~~. F ~~(this preserves the demagnetized condition of the as-sputtered medium). As such, there is no DC erase of the disks 14~~ from the time the magnetic material is sputtered on the disk 24~~s 14 are sputtered with magnetic media~~ to the time, after the disk 24 is assembled in the disk drive 40, that the ~~, until they are installed into the disk drive 100 before~~ servo patterns are written on the disk 24, there is no DC erase of the disk 24. This preserves the demagnetized condition of the magnetic material of the disk 24 and alleviates timing asymmetry. The disk 24 is demagnetized as follows:

(a) S

~~The conventional process of longitudinal recording includes DC erasing the data tracks of disks 14 in part or whole. One example of DC erase for part of the disk surface is performed during Write/Read offset measurements to determine the offset of the write and read element of the head. This embodiment of the method of the present invention ensures that the disks 14 are not DC erased, preserving the demagnetized condition of the as-sputtered magnetic medium on the surface of the disks 14. Referring to the example flowchart in FIG. 5, an embodiment of this method includes the steps of:~~ sputtering the magnetic material on ~~surfaces of~~ the disks 24~~14 with magnetic media in a sputtering process~~ (step 120~~52~~);

(b) Test the disk 24 ~~performing media test process~~ without DC ~~DC~~ erasing the disk 24~~s 14~~ (step 122~~54~~);

(c) I~~i~~nstall~~ing~~ the disk~~s~~ 2~~14~~ in the disk drive 4~~s 100~~ (step 124~~56~~); and

(d) S~~performing s~~ervo write and self-test the disk 24 ~~ing and test process~~ without DC erasing the disk 24~~e~~ (step 126~~58~~)~~. This method ensure a demagnetized state for regions of the disks 14 that are conventionally DC erased, and essentially alleviates timing asymmetry~~.

~~An example plot in FIG. 6A shows a timing histogram of differentiated data written after a conventional DC band erase. Two peaks are clearly present corresponding to the different lengths of positive and negative bit cells, showing bit shifts and timing asymmetry. Another example plot in FIG. 6B shows the same measurement for a data track written on as-received media after a disk sputtering process without any net magnetization, by turning off write current in regions that are conventionally be DC erased. This preserves the demagnetized condition of the as-sputtered medium, whereby timing asymmetry is eliminated. As such, after magnetic media is deposited on a disk surface, providing demagnetized ("raw") medium (i.e., random magnetization) such that data can be recorded on the disk surface, servo and user data are recorded on the disk without a conventional DC erase step. In one example, such a raw disk 14 is placed in a servowriter (not shown) or assembled in a disk drive 100 for writing data thereon, without a DC erase process.~~

~~Referring to example steps in~~ FIG. 9 shows a flowchart for demagnetizing the disk 24 in the disk drive 40 by DC erase with alternate polarity of the write current each time the transducer head 42 is stepped (radially repositioned relative to the disk 24). The disk 24 is demagnetized as follows:

(a) Move t~~7A, another method of demagnetizing (e.g., erase) the medium according to the present invention includes DC erase of the unused regions, but with alternating the polarity of the DC erase current each time the head is stepped (i.e., moved radially, wherein in one example step size is smaller~~

~~than the track pitch). In one version,~~ the transducer head 42~~25 is moved~~ to a first track 60 of an area- of the disk 24 ~~surface region~~ to be erased (step 13~~6~~0);

(b) ~~.~~Set t~~T~~he DC erase write current (such as 10 to 50 mA) for the transducer head 42~~is set~~ (step 13~~6~~2);

(c) ~~, and the head~~ DC erase (write) ~~s on~~ the current track 60 with the DC erase write current at a current ~~first~~ polarity (step 13~~6~~4);

(d) Determine whether the current track 60 is the last track 60 ~~. If other tracks remain~~ to be erased (step 13~~6~~6);

(e) Move the transducer head 42 to the next track 60 if another track 60 remains to be erased~~, the head 25 is moved/stepped to the next track~~ (step 13~~6~~8); and

(f) Reverse the~~,~~ polarity of the DC erase~~head~~ write~~/bias~~ current and repeat steps 134 and 136 ~~is reversed~~ (step 14~~7~~0).

Thus, steps 134, 136, 138 and 140 are repeated ~~, and the track is written (step 164). The above steps are repeated~~ until the desired area of the disk 24 has been ~~regions are~~ erased (step 142).

The transducer head 42 need not necessarily be stepped track-by-track. For example, the step size can be smaller than the track pitch.

FIG. 10A shows a magnetic field 150A from the transducer head 42 due to AC erase, FIG. 10B shows a magnetic field 150B from the transducer head 42 due to +DC erase, and FIG. 10C shows a magnetic field 150C from the transducer head 42 due to -DC erase. The magnetic fields 150A, 150B and 150C are generated by the write element 64 as the transducer head 42 writes to the disk 24. The magnetic field 150A occurs as the disk drive 40 performs AC erase on the disk 24, and the magnetic fields 150B and 150C occur as the disk drive 40 performs +DC erase and -DC erase, respectively, on the disk 24 with alternate polarity of the write current each time the transducer head 42 is stepped. The magnetic field 150A is represented by two vertical arrows and two

curved arrows, the magnetic field 150B is represented by two vertical arrows and three curved arrows, and the magnetic field 150C is represented by two vertical arrows and one curved arrow. Furthermore, the arrows represent a bubble where the transducer head 42 writes to the disk 24.

When the disk 24 is preconditioned with +DC erase only or with -DC erase only (depending on the direction of the write current), transition shift occurs. For example, when the disk 24 is preconditioned with +DC erase only, the magnetic bubble increases (the number of curved arrows increase), causing the written transitions to expand, and in turn causing transition shift. Likewise, when the disk 24 is preconditioned with -DC erase only, the magnetic bubble decreases (the number of curved arrows decrease), causing the written transitions to contract, and in turn causing transition shift.

When the disk 24 is preconditioned ~~FIGs. 7B-C show example diagrams of head flux 150 when the medium 14 is alternately~~ with alternate +/-DC erase and -DC erase as the transducer head 42 is stepped, ~~d, respectively, with write element 25b of head 25 according to the example method of FIG. 7A, wherein the~~ the $+B_{dc}$ magnetic field cancels the $-B_{dc}$ magnetic field and the net effect is similar to the AC e~~E~~rase.

FIG. 11A shows comparative plots of BER as a function of erase band width for AC band erase 160, +DC band erase 162 and -DC band erase 164. AC band erase 160 is according to the present invention, whereas +DC band erase 162 and -DC band erase 164 are conventional. The band erases 160, 162 and 164 are written to a disk, then tracks are written to the disk, and then the BER in a readback signal from the tracks is measured. As is seen, the AC band erase 160 has no appreciable impact on the BER, whereas the DC band erases 162 and 164 have a large impact on the BER.

FIG. 11B shows comparative plots of transition shift as a function of erase band width for AC band erase 170, +DC band erase 172 and -DC band erase 174. AC band erase 170 is according to the present invention, whereas +DC band erase 172 and -DC band erase 174 are conventional. The band erases 170, 172 and 174 are written to a disk, then tracks are written to the disk, and then the transition shift is measured. As is seen, the AC band erase 170 has no appreciable impact on the transition shift, whereas the DC band erases 172 and 174 have a large impact on the transition shift.

FIG. 12A shows a readback signal timing histogram of differentiated data written after a conventional DC band erase. The two peaks correspond to the different lengths of the positive and negative bit cells, which indicates bit shift and timing asymmetry.

FIG. 12B shows a readback signal timing histogram of data written on a disk with as-received sputtered magnetic material. The magnetic material is sputtered without any net magnetization, the demagnetized condition of the magnetic material is preserved, and timing asymmetry is eliminated.

FIG. 12C shows a readback signal timing histogram of data written on a disk after alternate +DC erase and -DC erase as a transducer head is stepped. Timing asymmetry is eliminated.

~~In one example, amplitude of the head current is about 10 to 50 mA. This method ensures a demagnetized state for regions of the disk that are conventionally DC erased, and essentially alleviate timing asymmetry. An example plot in FIG. 7D shows measurement of readback signal from data written on media 14 preconditioned by DC erasing with alternate polarity on adjacent tracks. The unused regions of the disk 14 are DC erased by alternating the polarity of the DC erase current each time the head is moved (e.g., step size smaller than the track pitch), whereby timing asymmetry is eliminated. The~~

~~above examples show benefit of eliminating the net magnetization in unused portions of a perpendicular recording medium (e.g., 50Gb/in^2).~~

The present invention has been described in considerable detail with reference to certain preferred versions thereof; however, other versions are possible. _Therefore, the spirit and scope of the appended claims should not be limited to the description of the preferred versions contained herein.

Abstract

D~~A method of d~~emagnetizing magnetic media for recording data in a data storage device.~~,~~ includes~~ing the steps of~~ placing the magnetic media in a magnetic field at a first strength~~ level~~,~~;~~ and gradually reducing the magnetic field to a second strength ~~level~~ to essentially eliminate net magnetization in the magnetic media.~~ Another embodiment includes the steps of determining a recording frequency for writing on the magnetic media with a transducer head, at which the amplitude of the transducer head readback signal from said portion of the magnetic media is essentially at noise level; and writing on the magnetic media at substantially said recording frequency, to substantially eliminate net magnetization in the magnetic media.~~